

Influence of irrigation scheduling on physiological growth parameters and yield of wheat under different sowing dates

ABSTRACT

Sowing time and irrigation play an important role to ensure higher production. Delay in sowing affects the growth and development of crop. Studying the effect of irrigation scheduling and sowing dates can provide a knowledge for improving production in late sowing conditions. A field experiment was conducted during the *rabi* season of 2020-21 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to study the influence of irrigation scheduling on physiological growth parameters and yield of wheat under different sowing dates. The experiment comprised of 12 treatment combinations having three sowing dates, 3rd December, 18th December and 2nd January in the main-plot and four Irrigation Water/ Cumulative Pan Evaporation (IW/CPE) based irrigation scheduling, viz. 1.0, 0.9, 0.8 and 0.7 in the sub-plot was analyzed in split-plot design with three replications. The findings of present investigation revealed that the physiological growth parameters and yield were higher in 3rd December sown date. Among the irrigation scheduling IW/CPE ratio 1.0 recorded significantly higher growth parameters and yield. The results of the present study conclude that adjusting sowing date with irrigation scheduling could assist in enhancing yield.

Keywords: Growth parameters, Crop Growth Rate, Relative Growth rate, Net assimilation rate, Leaf area duration, Yield

1. INTRODUCTION

Wheat (*Triticumaestivum* L.) is one of the most important cereal eaten in various forms in the world and is grown on 215 mha area with a production of 765 mt in the world [1]. In India, it is grown in an area and production of 29 mha and 103 mt respectively, in the year 2019 with productivity around 3420 kg ha⁻¹ [2]. In Madhya Pradesh, it covers 5.52 mha area during 2018-19 [3]. Wheat is a temperature sensitive crop. Delay in sowing exposes the crop to higher temperature that leads to accelerated maturity. Late sowing results in reduction in crop growth duration, it hastens crop phenological development [4] and hence, reduction in grain yield of wheat [5]. Extreme temperature during the grain filling stage has been identified as a major source of variation in wheat grain yield and quality characteristics [6]. Also, high temperature affects the net photosynthetic rate as it is sensitive for high temperature and hence, reduces the growth [7] and induces impairment of chlorophyll biosynthesis that results in less accumulation of chief photosynthetic pigment [8]. Hence, sowing time is a crucial factor affecting the growth and yield of wheat. It has been observed that a rise of 1°C temperature above the optimum level during grain filling stage, decreased the grain weight by 232.56 mg plant⁻¹ day⁻¹ [9]. Furthermore, irrigation play important role in proper growth and development of plant. Inadequate soil water during early growth stages results in reduction of plant population, dry matter production, which ultimately results in yield reduction. The water shortage at stem elongation and heading stages significantly lowered wheat yield [10]. Effective irrigation scheduling aims to provide adequate moisture at critical growth stages of the crop and it is crucial for sowing window as it may act as an intervention to cope up the

effect of warm weather conditions for late maturing crop. Hence, its efficient utilization is very important. Irrigation scheduling based on a climatological approach (IW/CPE ratio) is a scientific and useful approach for the efficient utilization of water. This approach merits special consideration of its simple operation and high-water use efficiency. Therefore, this study seeks to examine the effect of irrigation schedule based on IW/CPE ratio on physiological growth and yield of wheat under different sowing dates.

2. MATERIAL AND METHODS

A field experiment was conducted at Agricultural Engineering Farm, College of Agriculture Engineering, JNKVV, Jabalpur during the *rabi* season of 2020-21. The experiment comprised of twelve treatment combinations with three replications having three sowing dates, 3rd December, 18th December and 2nd January in main plots whereas in sub-plots, four irrigation schedules based on IW/CPE ratio viz., 1.0, 0.9, 0.8 and 0.7. The experiment was evaluated in split-plot design. The soil of experimental field was clay – loam in texture, neutral soil pH, medium in organic carbon content with NPK. Fertilizers were applied uniformly to all the treatment plots through urea, DAP and MOP @ 120:60:40 N: P₂O₅: K₂O. Half dose of nitrogen and full dose of phosphorus and potash was applied as a basal dose. Rest half dose of nitrogen was applied after first irrigation. During the period of experiment, the maximum temperature varied from 21.4 °C to 38.3 °C, and minimum temperature from 4.8 °C to 16.5 °C. The relative humidity (RH) varied from 11 to 88 percent during the crop season. The total rainfall received was 22 mm in 2 rainy days. The crop was exposed to total sunshine hours of 132.2 hours. The management practices for wheat (*Var.* MP3336) were done as per the recommendation of this region. For irrigation scheduling, a common come up irrigation was given just after the sowing after that water was applied as per the irrigation schedule based on IW/CPE approach i.e., 1.0, 0.9, 0.8 and 0.7 as per the formula by Parihar *et al.*, [11]

$$IW/CPE = \frac{\text{Depth of irrigation (mm)}}{\text{cumulative pan evaporation (mm)}}$$

The irrigations were applied as per the treatments using 5.0 cm depth of irrigation. There is a difference in the number of irrigations between the IW/CPE ratios. The herbicide Clodinafop-propargyl 15 % + Metsulfuron methyl 1 %, was applied at the rate of 60+4g/ha at 30 days after sowing wheat. Various growth parameters viz., Leaf area Index, chlorophyll index, crop growth rate, relative growth rate, net assimilation rate, leaf area duration were taken at periodical intervals. These are worked out by using the following formulas

2.1 Leaf area Index

The leaf area (m²) was measured with the help of leaf area meter (LI-COR, LI-3100C Area meter) and leaf area index (LAI) was calculated as per the formula given by, Watson [12]

$$LAI = \frac{\text{Total green leaf area of the plants (cm}^2\text{)}}{\text{Total ground area (cm}^2\text{)}}$$

2.2 Chlorophyll content

Chlorophyll content was taken with the help of a handheld chlorophyll meter (atLeaf+, FT Green LLC, Wilmilngton, DE, USA) and Chlorophyll content was calculated by the equation, Padilla *et al.*, [13]

$$Chl = 0.08 \times \text{atLEAF}^{1.63}$$

2.3 Crop growth rate (CGR) (g m⁻² day⁻¹)

Crop growth rate was calculated as per the formula suggested by Watson, [12] and is expressed in g m⁻² day⁻¹

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W₁ = dry weight of plant (g m⁻²) at t₁

W₂ = dry weight of plant (g m⁻²) at t₂

t₁ = time of first observation

t₂ = time of second observation

2.3 Relative growth rate (RGR) (g g⁻¹ day⁻¹)

It is worked out as per the formula given by Blackman, [14]

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where,

ln = natural log

W₁ = dry weight of plant at time t₁

W₂ = dry weight of plant at time t₂

t₁ = time of first observation

t_2 = time of second observation

2.4 Net assimilation rate (NAR) ($\text{g m}^{-2} \text{day}^{-1}$)

It is determined by formula suggested by Nichiporovich [15]

$$\text{NAR} = \frac{(W_2 - W_1)(\ln L_2 - \ln L_1)}{t_2 - t_1}$$

Where, L_1 and W_1 are leaf area and dry weight of plant at t_1 and L_2 and W_2 are the leaf area and dry weight of plant at time t_2 .

2.4 Leaf area duration ($\text{m}^2 \text{day}$)

It is worked out by the formula proposed by Watson [12]

$$\text{LAD} = \frac{(LA_2 - LA_1)(t_2 - t_1)}{2}$$

Where, LA_1 and LA_2 are leaf area at time t_1 and t_2

2.5 Statistical Analysis

The data obtained were statistically analyzed using OPSTAT software available online at CCS Haryana Agriculture University [16]. The data were tabulated and analyzed by using ANOVA [17]. The significant differences between treatment means were compared with critical differences at 5% levels of probability for F-test.

3. RESULTS AND DISCUSSION

3.1.1 Leaf area index

Leaf area is an important growth parameter that is related to crop yield. Leaf area index for different treatments is present in Table 1. Different sowing dates and IW/CPE ratio exerted a significant difference in all the treatments at different time intervals. It is observed that LAI increases with the increase in time period and reaches to maximum at 60 Days after sowing (DAS) after that declined due to senescence. Prasad [18] also observed decrease in LAI after 60 DAS upto 90 DAS. Among the sowing dates, a significantly higher leaf area index (1.84) was recorded at 3rd December sowing date followed by 18th December (1.76) and 2nd December sowing date (1.32). Shivani *et al.*, [19] also reported higher LAI than delayed sowing. Mishra *et al.*, [20] found higher LAI in timely sowing of wheat than in delayed sowing. Buttar *et al.*, [21] also noted decrease in LAI with the delay in sowing of wheat. Among the irrigation scheduling, IW/CPE ratio 1.0 observed higher LAI than 0.9, 0.8 and 0.7. This might be because of sufficient moisture availability by frequent irrigation at 1.0 IW/CPE. Throat [22] also noted more leaf area index with frequent irrigations. Butter *et al.*, [21] also noted an increase in LAI with the increase in amount of irrigation.

3.1.2 Chlorophyll content ($\mu\text{g cm}^{-2}$)

Data pertaining to chlorophyll content ($\mu\text{g cm}^{-2}$) is presented in Table 1. It is clear from the table that chlorophyll content increased upto 60 DAS after that it declined marginally upto 90 DAS. This might be because of senescence of crop. Among the sowing dates, 3rd December sowing date (38.33) recorded significantly more chlorophyll content than 18th December (37.03) and 2nd January (34.09) sowing date. This might be because of temperature stress conditions that resulted in lower chlorophyll content in the leaves. Throat [22] and Prasad [18] also reported a decrease in chlorophyll content with the delay in sowing. Among the irrigation scheduling, IW/CPE ratio 1.0 recorded more chlorophyll content than 0.9, 0.8 and 0.7. This might be because of sufficient moisture availability due to frequent irrigations in IW/CPE ratio 1.0 that might have lowered the effect of temperature thereby increasing the chlorophyll content of the leaves. The results are in line with the findings of Throat [22].

3.1.3 Relationship between Leaf area Index and grain yield

Regression analysis between grain yield with LAI and chlorophyll content showed a linear increase in yield with the increase in LAI and Chlorophyll content as shown in the fig 1. (a) and fig (b).

3.1.4 Relationship between LAI and grain yield

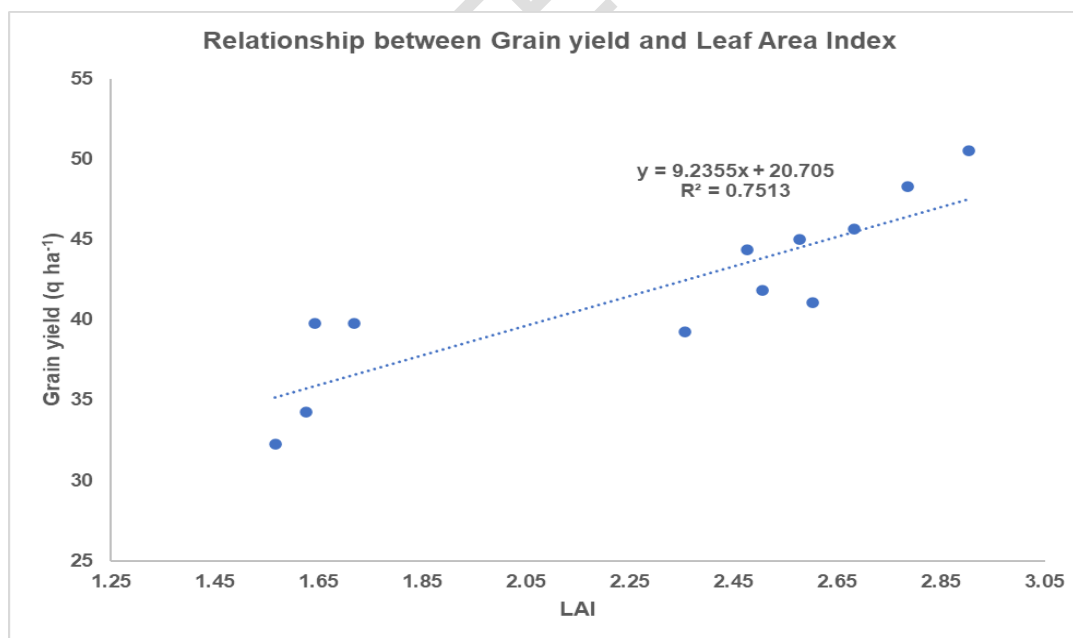
There was a positive significant relationship between leaf area and grain yield under different sowing dates and irrigation scheduling, fig 1 (a). This clearly shows that with the increase in leaf area index, the grain yield increases. The coefficient of determination shows 75 percent variation in grain yield. This might be because of a reduction in vegetative phase due to raised temperature faced at delayed sowing as also observed by Ram *et al.*, [23] and Ahmed *et al.*, [24].

3.1.5 Relationship between Chlorophyll content ($\mu\text{g cm}^{-2}$) and grain yield (q/ha)

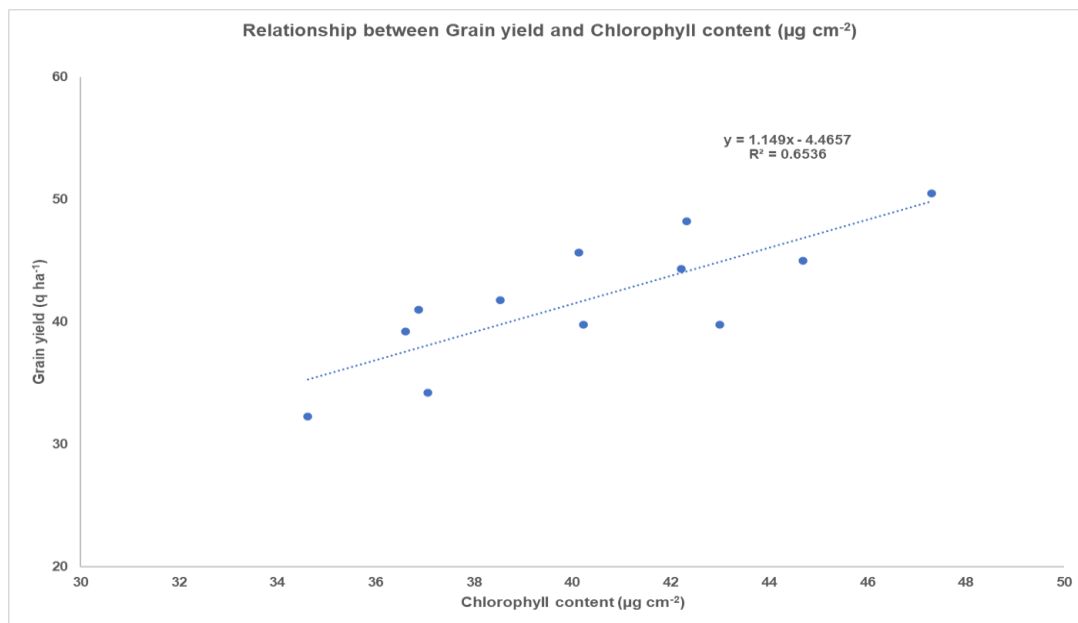
The graph clearly shows a positive significant relationship between chlorophyll content and grain yield under different sowing dates and irrigation scheduling, fig 1 (b). It is evident from the yield graph that with the increase in chlorophyll content ($\mu\text{g cm}^{-2}$), the grain yield increases. The coefficient of determination shows 65 percent variation in grain yield. Throat [22], Prasad [18] and Jain [25], also observed **more chlorophyll** content in timely sown crop than **in delayed** sowing.

Table 1. Influence of IW/CPE based irrigation scheduling and sowing dates on chlorophyll content and leaf area index

Treatments	Leaf area Index			Chlorophyll content ($\mu\text{g cm}^{-2}$)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Sowing dates						
December 03	1.84	2.74	2.64	38.33	41.65	38.61
December 18	1.76	2.48	1.96	37.03	40.50	35.52
January 02	1.32	1.64	1.48	34.09	38.72	32.97
SE m±	0.03	0.02	0.02	0.4	0.1	0.1
CD (5%)	0.11	0.06	0.08	1.6	0.6	0.5
IW/CPE ratio						
1.0	1.73	2.37	2.14	41.45	44.99	40.63
0.9	1.65	2.33	2.07	38.82	41.58	37.47
0.8	1.66	2.27	1.97	34.71	38.57	33.55
0.7	1.52	2.18	1.92	30.94	36.03	31.16
SE m±	0.05	0.02	0.01	0.5	0.3	0.4
CD (5%)	0.15	0.08	0.04	1.6	0.8	1.1



(a)



(b)

Fig. 1 Relationship between grain yield and (a) Leaf Area Index (b) Chlorophyll content ($\mu\text{g cm}^{-2}$)

3.2 Physiological Growth parameters

Data pertaining to physiological growth parameters is presented in Table 1. The data shows significant differences among the different treatments.

3.2.1 Crop Growth rate ($\text{g m}^{-2} \text{ day}^{-1}$)

It is clear from the Table 2 that the crop sown at 3rd December recorded a significantly higher Crop growth rate ($9.05 \text{ gm}^{-2} \text{ day}^{-1}$) than 18th December and 2nd January sowing date at 30-60 DAS. However, it was found to be non-significant at 60-90 DAS. This might be because of elevated temperature received by 18th December and 2nd January sowing date that resulted in a reduction in crop growth duration thereby attaining early maturity, accumulating more dry matter accumulation in a short period. Shivani et al., [19] and Lalita et al., [26] also observed similar results. Among the irrigation schedule, IW/CPE ratio 1.0 (9.27 and 8.23, respectively) recorded more CGR than other ratios at 30-60 DAS and 60-90 DAS. This might be because of sufficient moisture availability that resulted in accumulation of more dry matter, as also reported by Verma *et al.*, [27].

3.2.2 Relative Growth Rate ($\text{g m}^{-2} \text{ day}^{-1}$)

Results revealed that among the sowing dates, there is no significant different in RGR at 30-60 DAS. However, 2nd January (0.019) observed maximum RGR than the other sown dates at 60-90 DAS. This might be because of increased temperature that reduced crop growth duration. thereby, attaining successive growth stages earlier which increased dry matter accumulation in a short duration as compared to 3rd December sowing. As also observed by Lie et al., [28] and Pareek et al., [29]. Among the irrigation scheduling, IW/CPE ratio 0.7 (0.019) observed more RGR than other irrigation schedules at 60-90 DAS. This might be because of reduction of growth period that resulted in less dry matter accumulation. Also, lack of moisture resulted in less dry matter accumulation. Pal et al., [30] also observed less dry matter accumulation due to the lack of moisture. Deo et al., [31], Chouhan et al., [32] and Buttar et al., [21] also similar results.

3.2.2 Net Assimilation Ratio ($\text{g m}^{-2} \text{ day}^{-1}$)

Among the sowing dates, 2nd January (4.98) observed maximum NAR than the other sown dates at 30-60 and 60-90 DAS. This might be because of shorter length between the successive growth stages that resulted in more accumulation of dry matter in short period as also reported by Lalita et al., [27] and Pareek et al., [29]. Among the irrigation scheduling, IW/CPE ratio 1.0 (4.66) observed a maximum NAR than the other irrigation schedules moisture at 30-60 DAS. However, it was non-significant at 60-90 DAS. Availability of sufficient moisture at 1.0 IW/CPE ratio might have increased the crop growth duration that resulted in a more vegetative phase. But with the moisture stress condition resulted in early attaining the

successive growth stages in limited period thereby increasing accumulation of dry matter. As also reported by Pareek et al., [29].

3.2.4 Leaf area Duration (cm² day)

Crop sown at 3rd December observed more LAD at 30-60 DAS and 60-90 DAS than 18th December and 2nd January sowing dates. This might be because more leaf area that increased more photosynthetic activity per unit leaf area that leads to more LAD as also reported by Prasad [18]. Among the irrigation scheduling, IW/CPE ratio 1.0 observed maximum LAD than 0.9, 0.8 and 0.7 IW/CPE ratio. This might be sufficient moisture availability at 1.0 that contributed to fully turgid and open leaves thereby increasing photosynthetic activity of the plants. This also resulted in higher dry matter accumulation. Verma et al., [27] also observed that irrigation applied at 0.9 IW/CPE ratio recorded maximum values of growth indices.

3.3 Grain yield

Different sowing dates and IW/CPE ratios brought about significant variations in yield of wheat. Crop sown on 3rd December registered maximum yield (46.37 qha⁻¹). Among the irrigation scheduling, IW/CPE ratio 1.0 registered a maximum yield (45.10 qha⁻¹) than other ratio and was at par with 0.9 irrigation schedule. This could be because of suitable conditions and moisture availability that favoured proper growth and development of plant thereby increasing yield. As also reported by Throat et al., [33], Jain [24], Buttar et al. [21], Prasad et al., [8], and Lanjhewar et al., [34].

UNDER PEER REVIEW

Table 2. Influence of IW/CPE based irrigation scheduling and sowing dates on chlorophyll content and leaf area index

Treatments	Crop growth rate (g m ⁻² day ⁻¹)		Relative growth rate (g m ⁻² day ⁻¹)		Net assimilation rate (g m ⁻² day ⁻¹)		Leaf area duration (cm ² day)	
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
Sowing dates								
December 03	9.05	8.04	0.038	0.016	3.95	2.98	688697	808827
December 18	7.91	7.42	0.037	0.016	3.74	3.35	637108	667775
January 02	7.29	8.26	0.039	0.019	4.98	5.31	445779	469055
SE m ±	0.14	0.17	0.001	0.000	0.08	0.08	881.4	4017.5
CD (5%)	0.57	NS	NS	0.002	0.31	0.34	3553.6	16196.9
IW/CPE ratio								
1.0	9.27	8.23	0.038	0.016	4.66	3.85	616487	678315
0.9	8.43	7.96	0.038	0.017	4.31	3.81	598673	660932
0.8	7.76	7.81	0.038	0.017	4.05	3.89	591506	638617
0.7	6.87	7.64	0.037	0.019	3.86	3.97	555446	616345
SE m ±	0.15	0.12	0.001	0.000	0.12	0.08	10000.9	5496.1
CD (5%)	0.44	0.37	NS	0.001	0.34	NS	29944.3	16456.3

4. CONCLUSION

From the present findings, it can be concluded that 3rd December sowing date and IW/CPE ratio 1.0 brought about significantly higher growth parameters and yield. However, delayed sowing with the decrease in irrigation level has negative effects on crop growth and on yield. Also, a positive relationship was observed between chlorophyll content and leaf area index with grain yield. Thus, adjusting sowing dates and scheduling irrigation could assist in enhancing growth parameters thereby increasing wheat yield.

REFERENCES

1. FAO. 2021; fao.org/faostat/en/#data
2. Anonymous. World Agriculture Production by USDA. 2020; <http://ipad.fas.usda.gov/search.aspx>
3. Agricultural Statistics at a Glance. 2019; <http://eands.dacnet.nic.in>
4. Khande D, Agrawal KK and Bhan M. Phenology and heat unit requirement of wheat under various thermal environments and different methods of sowing in Tawa Command area of Madhya Pradesh. 2021; *Anveshak*. 51(2).
5. Agrawal KK, Shankar U, Upadhyay AP and Gupta VK. Accumulated heat unit requirements for different phenophases of wheat cultivars as influenced by sowing dates at Jabalpur. *Journal of Agrometeorology*. 1999; 1(2): 173-176.
6. Bogard M, Jourdan M, Allard V, Martre P, Perretant MR, Ravel C, Heumez E, Orford S, Snape J, Griffiths S, Gaju O, Faulkes J and Gouis JL. Anthesis date mainly explained correlation between post-anthesis leaf senescence, grain yield and grain protein concentration in a winter wheat population segregating for flowering time QTLs. *Journal of Experimental Botany*. 2011; 62: 3621-3636.
7. Mathur S, Agrawal D and Jajoo A. Photosynthesis: response to high temperature stress. *Journal of Photochemistry and Photobiology B: Biology*. 2014; 137: 116-26.
8. Prasad S, Agrawal KK, Kumar and Prakash V. Heat unit requirement of wheat cultivars under thermal regimes at Jabalpur. *Journal of Agrometeorology*. 2017; 19(3): 283-5.
9. Saini AD and Dadhwal VK. Influence of sowing date on grain growth duration and kernel size in wheat. *Indian Journal of Agriculture Science*. 1986; 56(4): 439-447.
10. Tari AF. The effects of different deficit irrigation strategies on yield quality, and water-use efficiencies of wheat under semi-arid conditions. *Agricultural Water Management*. 2016; 167: 1-10.

11. Parihar SS, Khera KL, Sandhu KS and Sandhu BS. Comparison of irrigation schedules based on pan evaporation and growth stages in winter wheat. *Indian Journal of Agronomy*. 1976; 68:650-653.
12. Watson DJ. The physiological basis of variation in yield. *Advances Agronomy*. 1952; 4: 101-145.
13. Padilla FM, Pean Fleitas MT, De Souza R, Gimenez C, Thompson RB, Gallarardo M. Evaluation of the Sensitivity of portable chlorophyll meter to estimate leaf Chlorophyll and N contents under excessive N conditions. Proceeding of 20th N workshop and side events- Rennes, France. June 2018.
14. Blackmann VH. Compound interest law and plant growth. *Annals of Botany*. 1919; 33: 353-360.
15. Nichiporovich AA. Aims of research on photosynthesis of plants as a factor of soil productivity. (In): Nichiporovich AA (Ed.) *Photosynthesis of productive system, Programme Science Translation Jerusalem, Israel*. 1967; 3-36.
16. www.hau.ernet.in
17. Gomez KA and Gomez AA. *Statistical procedure for Agriculture Research*, 2nd Edition, pp. 241-71. John wiley& sons, New York; 1984.
18. Prasad S. Effect of sowing time and nutrient management on growth and yield of heat tolerant varieties of wheat. Ph.D. Thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur; 2016.
19. Shivani, Verma UN, Kumar S, Pal SK and Thakur R. Growth analysis of wheat (*Triticumaestivum*) cultivar under different seeding dates and irrigation levels in Jharkhand. *Indian Journal of Agronomy*. 2003; 48 (4): 282-286.
20. Mishra V, Mishra RD, Singh M and Verma RS. Dry matter accumulation at Pre and Post anthesis and yield of wheat (*Triticumaestivum* L.) as affected by temperature stress and genotypes. *Indian Journal of Agronomy*. 2003; 48: 277-81.
21. Buttar PS, Kingra PK and Singh SP. Effect of Sowing dates, Irrigation and Mulching on Growth and Yield of Wheat. *Agric Res J*; 2018. 55(2): 243-250.
22. Throat TN. Assessment of wheat productivity using CERES-wheat model as influenced by varieties, planting dates and irrigation in Vertisols. Ph.D. Thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur; 2015.
23. Ram H, Gupta N, Mavi GS, Sarlach RS, and Singh G. Phenology, photo-thermal units requirements and productivity of wheat variety as influence by sowing dates under irrigated conditions in Punjab. *Journal of crop and weed*. 2017; 13(3): 73-77.
24. Ahmed BAM, Ahmad FE and Dessougi II. Assessments of relationship between effective leaf area, yield components and protein content in wheat

- (*Triticumaestivum*L.) under water stress conditions at Eastern Sudan sch. J. Agric. Vet. Sci. 2016; 3: 155-159.
25. Jain P. Fertilizer and water interaction for predicting wheat yield under varying thermal regimes in vertisol using CERES Wheat model. Ph.D. Thesis Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur; 2019.
 26. Bhayal L, Kewat ML, Aakash, Jha AK, Bhayal and Badkul AJ. Effect of sowing Time and nutrient management on physiological parameters of wheat. *Internationals Journal of Economic Plants*. 2022; 9(4): 271-275.
 27. Verma HP, Sharma OP, Yadav LR, Yadav SS, Shivran AC, Kumar R and Balwan. Growth indices and yield of wheat (*Triticumaestivum* L.) as influenced by irrigation scheduling and organic manures. *Journal of Pharmacognosy and Phytochemistry*. 2018; 7(1): 908-912.
 28. Lie J, He Q, Zhou G, Song Y, Guan Y, Xiao X, Sun W, Shi Y, Zhou K, Zhou S, Wu Y, Ma S and Wang R. Effects of sowing date variation on winter wheat yield: Conclusions for suitable sowing dates for dates high and stable yield. *Agronomy*. 2023; 13(4): 1304091
 29. Pareek B, Rana RS, Manuja S, Rana N, Pareek NK and Kumar. *The Pharma Innovation Journal*. 2022; 11(2): 1097-1101.
 30. Pal S, Kumar S, Gangwar HK, Singh A and Kumar P. Effect of scheduling irrigation based on IW/CPE ratio on dry matter accumulation, yield attributes, yield and Economics of Wheat crop (*Trieticumaestivum* L.). *Journal of Pharmacognosy and Phytochemistry*. 2020; 9(4):1946-1949.
 31. Deo K, Mishra SR, Singh AK, Mishra AN and Singh A. Water requirement of wheat crop for optimum production using CROPWAT model. *Journal of Medicinal Plants Studies*. 2017; 5(3): 338-342.
 32. Chouhan BS, Kaushik MK, Napelia V, Solanki NS, Singh B, Devra NS, Kumavat and Kumar A. Effect of sowing methods, scheduling of irrigation based on IW/CPE ratio and chemical weed control on plant height, dry matter accumulation and yield of wheat. *Journal of Pharmacognosy and Phytochemistry*. 2017; 6(3):169-172.
 33. Throat TN, Bhan M and Agrawal KK. Effect of sowing dates on weed infestation and yield of wheat (*Triticumaestivum* L.) varieties under different irrigation schedules. 2015; 49(1): 41-45.
 34. Lanjhewar A, Agrawal KK, Bhan M and Patel K. 2022. Influence of Thermal Regimes and Irrigation schedules on Growth, Yield of Wheat (*Triticumaestivum* L.) Varieties. 2022. *International Journal of Environment and Climate Change*. 12(12): 484-452.